DESCRIPTION OF THE BALÆNOPTERA MUSCULUS

IN THE POSSESSION OF

THE BOSTON SOCIETY OF NATURAL HISTORY.

By THOMAS DWIGHT, Jr., M.D.

V. Description of the Whale (*Balænoptera musculus* Auct.) in the possession of the Society: *with remarks on the classification of Fin Whales.* By Thomas Dwight, Jr., M.D.

Read May 17, 1871.

As a minute description of the skeleton of the most common species of Fin Whale may at first sight appear superfluous, it is desirable to state at once the purpose of this paper.

The classification of the Finners is in the greatest confusion, which is increased by the tendency of many zoologists to form new genera and species, ignoring the fact that the number of well described specimens is not sufficient to warrant much generalization. The task undertaken is to add one to the list of thoroughly described skeletons, and to endeavor to show that the range of purely individual variations is greater than is generally admitted.

The whale was a female, 48 feet long. The skeleton, just short of 45 feet (the curve being represented and the intervertebral cartilages suppressed), is now hanging in the large hall of the Society's Museum. Having no account which I know to be authentic of the capture of the animal, I copy a part of the commonly accepted one, from the *Boston Daily Advertiser* of Monday, October 17, 1870.

"A whale about sixty feet long was captured off Gloucester, on Saturday, and was towed up to this city yesterday, where it can be seen at Litchfield's wharf. We understand that the whale was first seen floating on the surface of the water by some fishermen, who supposed that it was dead. They went to it and succeeded in fastening a hawser to its jaws, when it began to 'come to' and soon gave unmistakable signs of life, thrashing round so that the boats were upset and the hawser parted. They, however, continued their attacks upon him, and after the third attempt they succeeded in putting a period to his existence, and a tow line round his jaw, which held. . . . . As far as had been ascertained, he had received no injuries before being seen by the fishermen, and it is supposed that its torpid condition was owing to sickness."

It was exhibited, according to this announcement, for about ten days, when the proprietor, Mr. H. T. Litchfield, having removed the blubber, presented the carcase to the Boston Society of Natural History. The flukes of the tail were cut off shortly after the capture, and the whalebone fell a sacrifice to the popular enthusiasm. While the whale was on exhibition and its destination still in doubt, Mr. J. A. Allen, of the Museum of Comparative Zoölogy, examined it and took many very accurate measurements. Mr. J. H. Blake, of the same institution, made the drawings which appear in plate VII, and woodcuts 1 and 2. All these were very handsomely given me by Mr. Allen, when the whale came into the possession of this Society. The carcase, by this time exceedingly offensive, was towed to an island in the harbor and dissected under the superintendence of Professor Hyatt, Mr. Sanborn and myself. As I was unable to be absent for a long time from the city, by far

the greater part of the work was done by these gentlemen, to whose ceaseless vigilance we owe the perfection of the skeleton. Decomposition being far advanced, the accommodations on the island barely comfortable for the season, and communication with the main

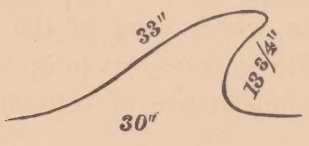


Fig. 1 — Dorsal Fin.

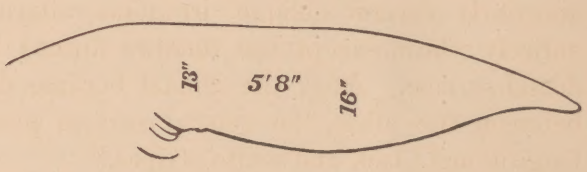


Fig. 2. — Flipper.

land irregular, all ideas of making a study of the muscles and viscera were abandoned, and all the care concentrated on the bones. (In this paper, to avoid too much repetition, I shall occasionally allude to this as the *Boston Whale*, it being the only large whale in the city proper, and the only specimen of this species that is likely to be here).

External Appearance. The following measurements and description are Mr. Allen's.

	ft.	*in.*
" Total length	48	
Circumference of the head at the eye	23	8
Distance from the eye to the end of the upper jaw	9	8
" " angle of the mouth to the end of lower jaw	11	1
" " eye to the blow-holes	3	6
" " " " auricular opening	2	3
" " " " base of the fore limb	4	11
" " end of the upper jaw to base of fore limb	14	7
" " dorsal fin to the fork of the tail	11	5
" " anus to the fork of the tail	14	3
" between anus and vulva	1	3
" " " umbilicus	6	8
" from the umbilicus to the fork of the tail	20	11
Length of the fore limb	5	4
Greatest width of the same	1	4
Length of the dorsal fin (measured along the anterior edge)	1	2
Breadth of the dorsal fin at base	2	7
" " tail two feet in front of the flukes	3	0
" " flukes at the base	2	7
" " tail just in front of the flukes	2	6
Distance from the median line of the back to the insertion of the fore limb	5	4
Distance between each flipper and the blow-holes	4	8
Length of the mammarial fissure	1	1
Length of the eye (entire length)	0	4.5
Breadth of the eye	0	1.83
Length of the eye ball	0	2
Breadth of the eye ball	0	1.75
Length of the blow-holes	0	6
Greatest diameter of each fissure	0	1.5
Distance apart posteriorly	0	6.5
Distance apart anteriorly	0	5

"The body is greatly compressed towards the tail, its vertical diameter two feet in front of the flukes being fully twice the transverse diameter at the same point. The greatest number of plicæ on each side of the median line was about twenty-eight. The color above was nearly uniform, slaty black, rather gradually shading off to white on the sides, with anteriorly several oblique, irregular, alternating bands of whitish and dusky. Below, entirely white, except the furrows formed by the plicæ, which were of the color of the dorsal surface. After the animal became distended with gases so as to open the furrows between the plicæ, the ventral surface presented the appearance of alternating narrow, longitudinal black and white stripes."

The whalebone, as already intimated, was quite destroyed by the public, hardly a single plate was left intact. No measurements have been made. Towards the end of the jaw it was white, or perhaps it would be better described as of a very light straw color; proceeding backward dark stripes became more and more numerous until ultimately, it was of a uniform dark slate color.

The Skeleton.

This is undoubtedly by far the best specimen of any large whale in America. It is but just short of theoretical perfection. The inferior epiphysis of one ulna was lost during preparation, and there are but sixteen chevron bones, of which some are imperfect. There is no evidence whatever that any others were overlooked or lost subsequently, though such an accident is of course possible. The whale had nearly reached the end of the young stage; the processes are well developed, but all the epiphyses of the fore limb became detached, and all those of the vertebræ except of the fifth caudal and one or two of those nearest the very end of the tail.

The Head.

During the process of preparation the following bones became loosened and were detached: the supramaxillaries, the premaxillaries, the nasals, the jugals, and the lachrymals. Moreover the conjoined petrous and tympanic bones of the right side have been removed; they have not been returned to the skull, but mounted as a separate specimen of the anatomy of the internal ear.

As the following table will show, the proportions of the head correspond very fairly with those given by Mr. Flower, of different heads of the *P. antiquorum* (Proc. Zoo. Soc., 1864, p. 411) and with those of the Rosherville whale. (P. Z. S., 1865, p. 216.)

DIMENSIONS OF HEAD (IN INCHES).

	in.
Length of skull in straight line	144
Breadth of condyles in straight line	11.75
" " " following curve	13.25
" " exoccipitals	44
" " squamosals (greatest breadth of skull)	67
Length of supra-occipital (along curve, just avoiding median spine)	29
" " orbital process of frontal (along lower surface from palatal)	27
Breadth of " " at base	26
" " " " at outer end	16

	in.
Length of nasals (in median line, upper surface)	6
Breadth of the two nasals at posterior end	3.75
" " " " anterior "	9.5
Length of beak	100
" " maxillary (by estimate)	112
Breadth of maxillaries across orbital process (following curve)	71
" " beak at base	50.5
" " " one quarter of length from base	36.5
" " maxillary at same point	12.75
" " premaxillary at same point	5.25
" " beak at middle	28
" " maxillary at same point	9
" " premaxillary at same point	4.25
" " beak at three-quarters length from base	19
" " maxillary at same point	4
" " premaxillary at same point	4
Length of lower jaw in straight line	137.5
Height at coronoid process	17.375
" " middle	10
Amount of curve	15.5

The proportion of the breadth of the skull to the length is a little more than 46.5 per cent., and that of the beak to the length a little less then 19.5 per cent.

Occipital Bone. — The various portions are completely coössified. The Basioccipital is pretty smooth and laterally concave. There is no indication of the point where it joins the basisphenoid. Its greatest breadth is 16 1-2 inches. The condyles, which are separated below merely by a slight groove, diverge as they ascend, so that at the point where they cease to bound the foramen magnum they are four inches apart. The length of a condyle along the curve is 13 inches, the greatest breadth 5 3-4 inches. The Exoccipitals, (Pl. VI, fig. 2 *a*), extend backward and outward, joining the squamous in a deep depression in which the posterior portion of the petrous bone lies. There is a rough tuberosity at about the middle of the posterior border of the exoccipital. The supraoccipital is elongated, which is one of the characteristics of *B. musculus*. The distance from the foramen magnum to the apex of this bone (avoiding the crest on the dorsum) is 28 1-2 inches. About eight inches above the foramen magnum a median longitudinal ridge appears, which reaches nearly to the superior angle. At a few inches from its origin it is very prominent; above, it gradually subsides. On either side, at about the middle of the lateral edge, over the highest point of the parietals, the bone bulges upward into a greater prominence (Pl. VI, fig. 1 *a*) than that of the occipital protuberance. A low, but distinct ridge crosses the middle of the bone transversely through the protuberance, but does not reach the edges. A long swelling (Pl. VI, fig. 1 *b*) moreover, passes upward and outward, describing a curved course from the condyles. It is worthy of note that this part of the occipital bone is marked by very uncommon prominences, particularly for so young an individual.

The Squamous Bone. — This bone may be divided into two parts, viz., an inferior or articular portion (Pl. VI, fig. 2 b), and a superior or temporal one. The former is, in the main, horizontal, and serves for the articulation of the lower jaw, the latter is, in the main, vertical, forming part of the wall of the temporal fossa.

The articular portion, viewed from below, has the form of an expanded concave plate

springing from a comparatively narrow base. It joins the exoccipital above the petrous bone, as already described; its internal edge is then free, till it meets the pterygoid, where it turns at a right angle and ascends, helping to form the external opening of the canal leading from the foramen ovale. The posterior border consists internally of a prominent ridge, which forms the posterior margin of a deep groove anterior to that for the petrous. Further out this groove passes into the upper surface as a large mass projects below it. The anterior border of the articular portion is a smooth vertical plate; towards the outer part of the lower edge there is a tuberosity. The external border is thick and curved. A straight line between its ends measures 27 1-2 inches, one following the superior convexity 41 inches. The superior surface is convex, marked towards its posterior end by several prominences; internally it is overlapped by the supra-occipital. The curve described is greater than I have seen figured in the *B. musculus* and is more like that of the *B. rostrata.*

The temporal portion passes forward from the anterior side of the articular portion. The superior edge is at first covered by the supra-occipital, but its anterior half is separated from it by a thin plate of the parietal. The anterior border of this portion presents two semilunar edges; the upper joins the parietal, the lower the alisphenoid, and the common angle projects between these bones. A very peculiar appearance must now be mentioned; a portion of this bone is in part cut off from the rest by sutures as definite as those separating distinct bones. A suture begins a little below the points of union of the two semilunar edges and runs upward and backward, parallel with the lower horn of the superior half-moon for about 6 inches, where, forming an acute angle with its previous course, it turns directly downward and ends suddenly in a foramen before reaching the lower border. Except in some trifling details this appearance is the same on the two sides.

The Periotic (or Petrous) Bone (Pl. VI, fig. 2 *c*). — As this bone has been removed from one side of the skull for the purpose of studying the internal ear, its minute description will be given in that connection, and it will here be sufficient to allude to its relations with the surrounding bones.

The bulla is very prominent; its long diameter is directed forward and a little outward The convex aspect faces outward and downward, and the edge of the carina bounds the *foramen lacerum posterius.* The posterior portion is seen pointing outward and backward, tightly wedged in between the squamous and exoccipital. The lower part of the anterior or pyramidal portion is seen as it enters a cavity between the squamous and pterygoid. A little of the labyrinthic portion is also seen in the depths of the fossa.

The Alisphenoid (Pl. VI, fig. 2 *d*). — As much of this bone as is visible from the outside may be divided into three parts, viz., an inferior horizontal portion on the base of the skull, an external one in the temporal fossa, and a pterygoid portion springing in part from each of the others. The inferior portion is about 12 inches long, articulating internally with the vomer. Anteriorly it is overlapped by the palatal, till at the middle of its outer border it bends down to form the internal pterygoid plate; behind, this the border is free. The external portion of the bone is situated in the deepest part of the temporal fossa. It is bounded behind by the squamosal, above and in front by the parietal and the small interposed scale of the basisphenoid. The surface is here concave, but below, as it grows narrower, it becomes convex and makes a bold turn downward and inward forming the external pterygoid plate, which is in contact with the palatal bone anteriorly. The base of

the internal pterygoid plate is separated from the inferior portion of the bone by a longitudinal groove. The plates meet anteriorly at an acute angle under cover of the palatal. They enclose a deep cavity which is bounded below by the hamular process, 4 1-2 inches in length and pointing backward and outward. It assists to form a deep notch with the posterior edge of the external plate. The length of the pterygoid process from the outer opening of the foramen ovale is 8 1-2 inches.

The Parietal. — The surface is concave and forms the greater part of the temporal fossa. The superior border is convex upward and outward. Beginning to follow its course from behind, it is first seen between the squamous and the supra-occiptal; at the upper end of the latter it sends a triangular portion inward between it and the frontal (Pl. VI, fig. 1 *c*), which it then begins to overlap. The anterior edge passes backward and downward, turning round the root of the orbital plate. The posterior inferior border is convex and articulates above with the squamous, and lower down with the alisphenoid, from which it is in part separated by the basisphenoid.

The Basisphenoid. — As there is no suture between this bone and the basioccipital, and as the neighboring parts, with the exception of one petrosal, have been quite undisturbed, no description of it would be possible were it not for a small piece visible in the temporal fossa. This piece has been identified as a portion of the basisphenoid from information derived from the works of other observers, for it would be impossible to name it from the little that is seen on the unopened skull. It is about 4 1-2 inches long; its greatest width is 3-4 inch. It is placed nearly horizontally. The posterior end is pretty solid, but the anterior thin and scale-like, and pointing a little downward. It is between the alisphenoid below and the parietal above. In the *B. rostrata*[1] it appears also to touch the squamous, but in this specimen it is separated from it by about three inches. It is remarkably symmetrical on the two sides.

The Frontal. — The bones of the two sides are distinct. The portion nearest the median line is in front of the supra-occipital and of an internal prolongation of the parietal. This part extends forward and outward into a number of delicate laminæ, most of which interdigitate with those of the frontal process of the superior maxilla, but a few internal ones with those of the intermaxilla. A V-shaped cavity in the median line is formed by the two frontals, with a little ridge in the middle for the nasals. Below this the frontal is bounded by the ethmoid, and on the side overlapped by the parietal. The superior border continues free till it reaches the anterior internal angle of the orbital plate, which is hidden by the superior maxillary. This border is 18 inches long. The surface which it bounds is at first vertical, but soon becomes horizontal, forming the supra-orbital plate (Pl. VI, fig. 1 and 2 *e*). This plate is irregularly quadrilateral. The posterior edge bounding the temporal fossa in front is 22 1-4 inches long, reckoning from the parietal. It is thick, and marked by two semilunar depressions, of which the internal is much the larger and very rough. The anterior border is of about the same length, and very thin except at its outer end; it fits more or less accurately into a groove on the upper surface of the maxilla. These two borders converge decidedly, as is characteristic of the *B. musculus*; the anterior is by far the most oblique. The breadth at the base is from 25 to 26 inches; at the outer edge of the plate it is about 16 inches. This end is very thick; it is marked behind by a tuberosity where

[1] Carte and Macalister, Trans. Royal Soc., 1867, p. 201.

it overhangs the squamous, and in front by a smaller one which articulates with the lachrymal. The under side is concave, forming the roof of the orbit. The distance in a straight line between its prominent extremities is 9 inches. The concavity is soon increased into a groove which runs into a canal representing the continuation of the optic foramen (Pl. VI, fig. 2 *f*). This forms a prominent ridge along the posterior border of the inferior aspect of the orbital plate. The greater part of the remainder of this surface of the plate is hidden by the superior maxillary. There is a depression towards the base.

The Ethmoid.— This bone is not easily studied owing to its position, and has in this case suffered a good deal on account of its softness. It probably was never very distinct from the rostral cartilage. There is now to be seen an irregular crumbling bone, filling the posterior end of the cavity between the plates of the vomer. A plate passes upward from either side to meet its fellow in the middle, on the under surface of the frontal. This may perhaps be considered the orbital surface, though it is very deeply placed. In the *B. rostrata* (loc. cit.) it is said to reach as far back as the pterygoid bone; in this case it does not approach it. At the junction of these plates the bone spreads out laterally for a short distance, supporting the frontal.

The Vomer (Pl. VI, fig. 1 *f*, fig. 2 *g*). — The vomer consists of a horizontal portion fitting on to the base of the skull, and of two plates forming the rostrum. The former portion rests on the basisphenoid, and curves downward on either side to meet the internal edge of the pterygoids. It is most expanded at the posterior end, measuring 10 1-2 inches in a straight line between the angles. It begins to contract almost at once, but expands in front of the pterygoids to meet the palatals; still more anteriorly it bends upward and joins the frontals. A little more than an inch in front of the posterior edge a median ridge begins to appear, which soon becomes prominent, and sweeps boldly downward to form the beginning of the rostrum. Towards the end of its course it turns suddenly backward, so that the spine of the rostrum overhangs its posterior edge. The entire length of the vomer is 10 feet 1 inch, that of the spine of the rostrum 9 feet. The two plates meet at first at a very acute angle, which becomes more obtuse towards the apex. The greatest depth of the bone is in the neighborhood of the anterior end of the palatals, where it amounts to 13 inches. The superior edges of the plates, at first thin, become thick in the nasal region where they articulate with the superior maxillaries, but become anteriorly very thin and scale-like.

Palatal Bone (Pl. VI, fig. 2 *h*). — This bone consists of a thin plate lying on the outer side of the vomer. The posterior end is the most solid part and articulates with the anterior edge of the pterygoid; it reaches superiorly into the angle between that bone and the frontal, and then expands on the under surface of the latter. From the lower end of the pterygoid the border passes inward to meet the projecting spine at the beginning of the rostrum of the vomer. The remainder of the lower border measures nearly 26 inches. On reaching the supramaxillary the border turns upward and passes into the superior one by a rounded angle. The anterior part of the superior border is marked by a deep groove for the maxilla. Near the posterior superior angle there is also a slight groove passing downward and backward with an elevation below it.

Superior Maxilla (Pl. VI, fig. 1 *g*, fig. 2 *i*). — This is best considered as a pyramid with a superior, an internal, an inferior surface and a hollowed base for its posterior attachment. The greatest length is 9 feet, to which about 2 inches may be added owing to injury of the

point. *The superior surface* is convex both longitudinally and laterally. It is bounded behind by a curved ridge, concave backward, which connects the nasal and zygomatic processes, and which overhangs the anterior internal angle of the orbital plate. The nasal process is the continuation of the internal part of this surface. It begins so gradually that the length cannot be given; at its posterior end it is 5 inches broad. Below its smooth upper surface it consists of a number of very delicate plates to articulate with others from the frontal. The zygomatic process is directed outward, downward and backward. The outer border runs in a straight line to the tip, but the internal is concave towards its posterior end, so as to increase the breadth of the nasal opening. This upper surface is marked by seven foramina on the left bone, and twelve on the right; the latter, however, are smaller. They present no regularity except in opening forward and outward, and in being confined to less than the posterior half of the bone.

The internal surface is nearly at right angles with the superior, and is also triangular. Posteriorly it runs into the nasal process; below and in front of which it forms part of the wall of the nasal cavity, in which it begins to bear a prominent longitudinal ridge which overlaps the lateral plate of the vomer, and is soon included between that and the intermaxillary. The lower part of the posterior border shows a curve corresponding to the anterior convexity of the palate bone. *The inferior surface* may be said to be concave in all directions; it is marked by some twenty-four foramina and grooves; though very irregular these may be divided into two classes, the first consists chiefly of grooves running forward along the median or vertical part of this surface, the second forms part of a circle of foramina, pointing towards the periphery of the bone. They are in places arranged in a double row, one opening just internal to the other. The internal posterior angle is free, hanging under the orbital plate of the frontal, and a little external to the palatal; the posterior edge is irregular in outline; just before reaching the outer angle it presents a small concavity with which the jugal articulates very accurately. The concave *base*, quite hidden when the bone is in place, does not require a minute description, its chief peculiarity consists in the large foramina communicating for the most part with one another, by which the canals begin which convey the nerves and vessels to the various openings already mentioned.

The Intermaxillary (Pl. VI, fig. 1 *h*, fig. 2 *j*). — Greatest length 8 feet 11 inches, with about one inch to restore. For about the anterior three-fourths of its length it presents three surfaces and three borders. The superior is smooth and of denser structure than the others; it forms a continuous surface with the superior maxillary; the external surface is in apposition with that bone and is in no way peculiar. The internal and inferior is concave. At about two-thirds of the length of the bone from before, the edges cease to be sharply defined, and the bone becomes thin and twisted upon itself in such a manner that the superior surface becomes the internal, forming the outer wall of the nasal cavity. At its extremity the bone ends in a few vertical scaly plates, which interdigitate with others from the frontal.

The Nasal (Pl. VI, fig. 1 *i*). — This is a wedge-shaped bone with a concave base and a blunted edge. The thin end which is directed backwards is rough to articulate with the frontal. The internal surface, which is in apposition with that of the other bone, is smooth, but marked by some curved lines running downward and forward. The outer surface is received into a depression chiefly in the frontal, but in part in the intermaxillary. Its

upper and lower borders converge. It ends in two prolongations, of which the superior rests on the intermaxillary bone, and the inferior, which is longer, reaches almost to the maxillary — very possibly quite to it in the fresh state. The anterior surface is concave from side to side, being inclosed by the median and lateral prominences. It becomes narrow as it turns on to the upper surface, and passes to the outside of a median triangular elevation. The under surface is smooth and bounded anteriorly by an oblique line running forward and inward. When the two nasals are in position they form a prominent spine in the median line.

The greatest height (*i. e.*, vertical length) taken near the posterior end is 10 1-2 inches. The other dimensions can be found in the table of measurements.

The Malar (Pl. VI, fig. 2 *k*). — This is a thin bone; broad in front, narrow behind; concave above, convex below. The lower surface is marked near its anterior end by a wavy ridge which articulates with the posterior border of the superior maxillary. On front of this ridge the malar is thinner and overlaps the adjoining bone. The upper surface bears at its anterior extremity a depression for union with the lachrymal. The outer edge is thick; the inner thin. Towards the front of the outer border there is a deep notch, the continuation of a groove on the upper surface. The greatest length of the bone is 9 3-4 inches; It ends behind in a spine 3-4 inch long, pointing directly inward.

The Lachrymal (Pl. VI, fig. 2 *l*) is in shape an oblique parallelogram with rounded angles, placed transversely between the frontal and the outer angle of the superior maxilla. It helps to form the orbit anteriorly. Only a very small portion projects outwards. The inferior surface presents a depression for articulation with the malar.

The Mandible. — The lower jaw is very solid and heavy. It is strongly curved, the greatest convexity being rather behind the middle. The head, which forms the posterior end of the bone, is of ovoid shape, with the long diameter running downward and outward. It is separated from the body by a groove running outward and a little downward on the hinder aspect. The neck is constricted laterally, but the sides retain their convex form. It is marked below by a rough line, above by a sharp ridge which runs forward and turning downward forms the edge of the roof of the dental canal, overhanging the entrance. The coronoid process extends upward and outward and ends in a blunt knob. Its posterior border is nearly vertical, its anterior is very oblique, and gradually subsiding forms the superior division between the outer and inner surfaces. The body decreases in size very gradually; the outer surface is convex, the inner nearly plane, except near the anterior end where its upper portion overhangs the inferior, forming a groove. The opening of the dental canal is situated a little behind a line dropped from the posterior border of the coronoid. A groove containing many small foramina runs along the upper part of the internal surface, just inside of the bounding line. Several larger foramina are placed in a row on the upper part of the convex outer surface. These latter are eight in number on the left side, and eleven on the right.

Hyoid. — The basihyal with the coössified thyro-hyals presents the appearance characteristic of the species. The body is nearly flat, and the thyro-hyals, at first very solid, taper towards the end and are bent strongly upward. The anterior cornua which surmount the body are nearly two inches long, and but about half an inch apart. There is a median notch on the posterior border of the body with a slight tuberosity on either side. Its superior surface is deeply grooved in the middle. The antero-posterior diameter of the body in

the median line is 4 3-4 inches. In a straight line between the ends the bone is 24 1-2 inches broad; following the convexity 31 inches. The circumference of the thyro-hyal at its extremity is 7 inches, and midway between this point and the centre of the bone 11 1-4 inches.

The Stylo Hyal.—This is 15 inches long in a straight line, and 16 inches following the convexity. It is compressed above and below, except at the very inner end where the vertical diameter is the greatest. The outer end is but 1 inch thick.

Vertebræ.

The vertebral formula is 7 cervical, 15 dorsal, 15 lumbar, 26 caudal. As the cervical vertebræ are always described as of particular importance for classification in spite of the considerable variations which they exhibit, it is advisable to describe each one separately, so that accurate comparisons can be drawn between corresponding bones in different skeletons. The vertebræ of the other regions will be considered in a different manner.

Atlas.—This bone, like that of the Rosherville specimen described by Mr. Murie (P. Z. S., 1865, p. 217), resembles Gray's figure of the atlas of the *P. Duguidii* rather more closely than that of the *P. antiquorum* in the thickness and obtuseness of the transverse processes, the greater length of the neural spine and the greater interval between the inferior ends of the anterior articular surfaces. The anterior aspect is formed by the articular surfaces and the transverse processes. The greatest length of the articular surfaces is 10 1-4 inches, the greatest breadth 5 1-4 inches; they are deeply concave and surrounded by a slight groove, separating them from the outer aspects of the bone. The superior extremities of these cavities are 5 inches apart; the inferior 3-4 inch. The opening between them is 7 1-4 inches long; it becomes constricted about the middle, the superior half forming the continuation of the spinal canal, the inferior being closed by the body of the axis.

The posterior surface presents the same general outline, but the two articular surfaces are united into one by an isthmus 1 1-2 inches in breadth, across the inferior part of the bone. They do not form the lateral boundaries of the canal, but are separated from it by about 1 inch of smooth bone. The arch is marked above by a longitudinal spine in the median line with a prominence at either end. The anterior border is sharp, but presents a tubercle at the point of union with the articular surfaces, which forms the roof of a canal opening directly external to it (Pl. vi, fig. 4 *a*). The lower edge of the arch is thick and presents a smooth surface (Pl. vi, fig. 4 *b*) on each side of the median line for articulation with corresponding ones on the arch of the axis in serial homology with the zygapophyses. There is a slight prominence projecting backward in the median line. The tranverse process has a broad vertical base from which it gradually tapers. Towards its point it is twisted upon itself so that the anterior surface of the base becomes the inferior near the apex, and the posterior in like manner becomes the superior. On the superior aspect of the bone the tranverse process springs from a prominent tubercle (Pl. vi, fig. 3 *a*, fig. 4 *c*) on the posterior border. Nutrient foramina enter the bone on the front and back of the base of the transverse process.

Axis.—The Boston whale, unlike the Rosherville one, resembles in this point the drawing of the *P. Duguidii* and not that of the *P. antiquorum*; Gray's drawing of the former

would almost answer for this case were it not for the greater depression which the Boston whale presents in the inferior surface, and for a slight difference in the external border of the lateral portions. The anterior surface has an articular portion of the usual shape corresponding to that on the posterior side of the atlas. The odontoid process (Pl. VI, fig. 5 *a*), is about 1-2 inch in height, and presents a depression in its summit like the crater of a volcano. The posterior surface has a deep vertical depression in the middle, which is continued into a notch in the upper and lower sides. The two halves of the body share in the inclination of the transverse processes; these are broad masses enclosing a large foramen 5 1-2 inches on the left side, 4 1-8 inches on the right, which shows of how little value such features are for classification. The parapophysis, which forms the inferior boundary, is broader and stouter than the diapophysis, which forms the upper. The transverse processes are directed backward, as shown in fig. 7. Two tuberosities forward inclining, of which the internal is the larger, separated by a slight groove, are seen on the superior edge of the diapophysis over the foramen (Pl. VI, fig. 5 *b*). The spinal canal has a breadth of 5 1-8 inches to a height of 4 1-2. The arch presents a slight ridge in the median line, and a prominence on either side projecting forward and upward; that on the right is the larger. On the anterior aspect of each of these prominences is a smooth plate (Pl. VI, fig. 5 *c*), the real zygapophysis; the posterior ones (Pl. VI, fig. 6 *a*) are on the outer sides of the arch.

The other cervical vertebræ show the usual amount of individual variation when compared with descriptions and figures. The rings formed by the transverse processes are complete in the 4th or 5th, and very nearly in the 3d. In the latter the interval is of only about 1-4 inch on the right side; on the left it cannot be accurately determined, as a small piece has been broken off. In the 6th the inferior processes are very small, that of the left side, however, being more than twice as large as its fellow. They exist in the 7th only as slight ridges. After this description of the first two and slight sketch of the remaining cervical vertebræ, it appears well to study in connection with the following table of measurements the modifications which each element of a vertebra undergoes in the entire column, and to compare them with those in other specimens.

Vertebræ.	Greatest width between extreme points of transverse processes.	Greatest height of body and neural spine.	Greatest width of body.	Greatest height of body (in median line).	Greatest length of body.	Breadth of transverse processes near tip (antero post.).	Breadth of neural spine near tip.	Distance between anterior points of metapophyses.
Cervical.								
1	21	12	12.5		4.25	2.5	4.5	
2	29.25	12	12.5	6.5	3		2.75	
3	25.87	11	11	6.5	1.87		2.5	
4	26.12	11.25	10.75	7	1.75		2.12	
5	26.25	11	10.75	7.12	1.75	.25	1.87	
6	25.25	11.37	10.5	7.5	2	.37	2	
7	26.25	12.37	10.5	7.5	2.25	1	2.5	
Dorsal.								
1	26	12.37	10.75	7.5	3	1.5	1	10.5
2	24.25	13.37	10.75	7.37	3.5	2	1.5	11
3	24	14.75	11	7.12	4.25	4.25	3.25	10.75
4	26	17	10.75	7.25	5.12	5.75	5	9
5	28	18	10.37	7.25	5.62	6.5	5.75	7
6	29.25	18.75	10.25	7.25	6	6.5	6	4.75
7	30.62	19.75	10	7.25	6.25	6.5	6	4

Vertebræ.	Greatest width between extreme points of transverse processes.	Greatest height of body and neural spine.	Greatest width of body.	Greatest height of body (in median line).	Greatest length of body.	Breadth of transverse processes near tip (antero post.).	Breadth of neural spine near tip.	Distance between anterior points of metapophyses.
Dorsal.								
8	31.25	20.5	10	7.5	6.75	6.75	6.75	3.25
9	31.5	21.25	10.25	7.5	6.75	6.5	6.62	3.62
10	31.5	21.62	10.25	7.75	6.87	6	6.62	3.25
11	32.5	22.12	10.37	8	7	6.25	6.37	3.12
12	33	22.25	10.25	8.12	7	6.25	6.5	3
13	33.75	22.5	10.25	8.25	7	6.5	6.62	2.87
14	34.5	22.75	10.25	8	7.25	6.5	7.37	2.62
15	34.12	23	10.25	8.62	7.5	5	7.5	2.5*
Lumbar.								
1	33.75	23.25	10.5	8.5	7.5	5.75	6	2.75
2	34	23.5	10.5	8.5	7.5	6.12	6.25	2.75*
3	35	23.62	10.75	8.75	7.75	7.37	6.5	2.75
4	34.75	24	10.75	9	7.87	7	6.62	2.75
5	34.25	24.5	10.75	9	7.75	6.75	6.25	2.75
6	33.62	24.75	10.75	9	8	7.25	6	2.87
7	33.75	24.12	10.75	9	7.87	6.87	7	2.62
8	32.62	24.87	10.75	9	8.25	6.75	7	2.87
9	32.62	25	11	9	8.12	6.75	6.5	2.75
10	31.75	25	11	9.25	8.25	6.75	7.37	2.87
11	30.62	25	11	9.25	8.25	6.87	7.5	2.87
12	29.25	25.12	11.25	9.5	8.75	6.75	7.12	3
13	27.5	24.87	11.5	9.5	9	6.12	7.12	3.25
14	26.5	24.75	11.5	9.62	9	6	6.87	3.12
15	25	24.25	11.5	9.5	9.25	7.12	6.62	3.62
Caudal.								
1	23.25	24.25	11.75	9.75	9.25	6.5	6.75	4.25
2	22.37	24	11.5	10	9.25	5	6.37	3.87
3	21.5	23.25	11.75	10.12	9.12	4.5	6.25	3.5
4	20.75	21.5	11.5	10.25	9.25	4.25	5.62	3.75
5	19.62	19.87	11.75	10.5	9.37	4.5	4.25	4.5
6	17.75	18.25	11.5	10.12	9.5	4.12	3*	3*
7	16.75	17.5	11.75	10.25	9.37	4.37	2.62	3*
8	15.25	17	11.75	10.25	9.25	4.87	2.5	3.62
9	14	15.5	11.5	10.12	9.12	5	2	3
10	12.87	13.87	10.75	10	9	4.75	1.75	1.5
11	11.87	14	10.62	10	8.75	2.5	2.25	1.5
12	11	13.12	10	9.75	8.5	2.25	2	1.75
13	9.62	11.37*	9.37	9.25	8.12	1.5*	1.75	1.25
14	9.25	10.62	8.62	9	7.25		2	1
15	7.37	9	7.37	7.25	5.25		1.25	
16	6.75	6.75	6.75	6.75	4			
17	5.75	5.87	5.75	5.87	3.62			
18	5.12	5.25	5.12	5.25	3.37			
19	4.37	4.37	4.37	4.37	3.12			
20	3.75	3.62	3.75	3.62	2.87			
21	3.25	3.25	3.25	3.25	2.5			
22	2.5	2.5	2.5	2.5	2			
23	2.12	1.87	2.12	1.87	1.62			
24	1.25	1.5	1.25	1.5	1.37			
25	1.25	1	1.25	1	1			
26	.87	.87	.87	.87	.62			

The Bodies. — In the axis the two lateral halves of the body are symmetrically bent backward. The 3d, 4th, and 5th vertebræ present a similar appearance; the last, however, very slightly. In all the others the ends are about plane, till the 13th caudal, which

* The star indicates that some point of the vertebra is slightly injured, so that an *absolutely* accurate measurement could not be made.

has a slight central depression on its posterior extremity. This depression becomes more marked in the succeeding ones, and after the 16th a similar one is seen on the anterior extremity. The 23d is convex posteriorly, and the three remaining are too evidently irregular to deserve description. The 3d cervical presents a depression in the upper and lower border, which is marked by a prominence in the median line, that below being double, but single in those following. In the 4th the depressions are very slight, and in the 5th are wanting. The superior median prominence continues throughout the cervicals, though gradually decreasing; the inferior becomes more marked, and in and after the 4th dorsal is very striking, showing a prominent longitudinal ridge. In the 5th, 6th, and 7th it gradually disappears, but returns in the 13th, and increases till it attains its greatest development at about the middle of the lumbar region. In the 15th lumbar it shows signs of bifurcation towards the posterior end. In the 1st caudal these prominences become marked for the attachment of the chevron bones, and we now have two lines with a median depression between them. In the 4th caudal lesser prominences appear at the anterior end. The depression continues to grow deeper, and as the bodies become shorter the elevations on the ends of these lines are naturally brought nearer together, till in the 13th they unite, forming a ridge perforated by a foramen corresponding to the previously existing notch In the 15th the bone has become so much modified that there is merely a single protuberance on either side of the foramina which enter the inferior surface of the bone, and presently this disappears entirely. The superior surface of the body forming the floor of the spinal canal loses, as already stated, the central ridge with the first dorsal vertebræ, and after that is marked by a concavity in its centre, its anterior and posterior borders remaining straight. This concavity is most marked about the middle of the dorsal region. The proportions of the bodies can. be seen by reference to the table. At first they are broad and thin in the cervical, but later the height and length increase, till in the anterior caudal region the three diameters are not very different. In the 14th caudal the height for the first time surpasses the breadth. In the 15th dorsal the length approaches to within 1-4 of an inch of the height, but as the latter then increases the discrepancy continues till we reach the 23d caudal. These proportions agree very well with those to be deduced from

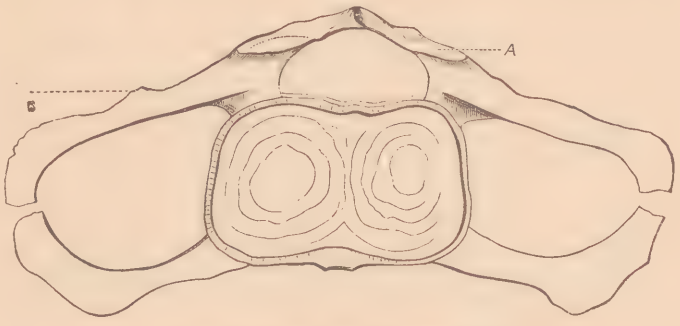


Fig. 3. — 3d Cervical Vertebra.

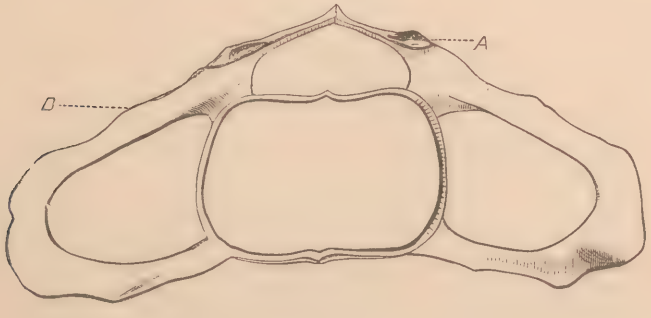


Fig. 4. — 4th Cervical Vertebra.

Mr. Murie's table in the case of the Rosherville whale. I do not remember any account of the aortic impression in the whale; in this one, however, it is very striking. As the inferior surfaces of the body are more or less concave with prominent borders, it is in the outline of the epiphyses that this depression is most evident. The 10th dorsal vertebra is the first in which it is distinct, though there is a suspicion of it in the 8th and 9th. It becomes more developed in the 11th, 12th, and 13th, after which in the 14th and 15th it quite destroys the symmetry of the bone, forming a depression along the left side of the body. It is less marked in the 1st lumbar and barely perceptible in the 2d, after which there is no trace of it.

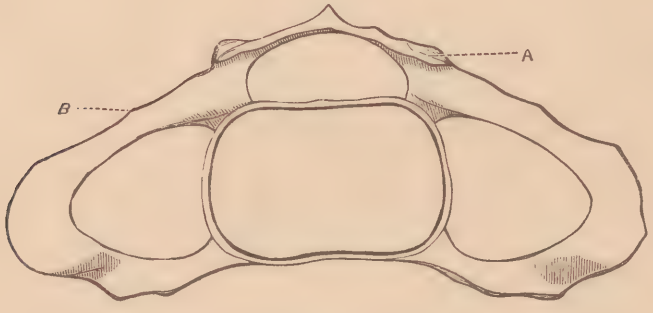


Fig. 5. — 5th Cervical Vertebra.

The foramina being in a great degree dependent upon modifications of the processes, will be considered separately, as will be also the last few vertebræ.

Spinous Processes. — These processes are represented by mere ridges in the cervical vertebræ, except the 7th, where there is a decided elevation. In the 3d dorsal it is very much larger and broader than in the 2d, and the 4th presents even a greater increase. After this the difference is less. In the 8th dorsal a slight backward inclination is manifest, which increases with the height (reckoning with the latter that of the body of the vertebra), till both reach their maximum in the 12th and 13th lumbar. Beyond this point the height rapidly decreases, though a considerable inclination persists. The 14th caudal is the last vertebra which can be said to have a spinous process. The processes are more or less rounded at the top, and the measurements in the 7th column of the table are taken just below the termination, so as in most cases to give the greatest breadth (antero-posteriorly). In the 5th dorsal a posteriorly projecting spine arises from the base of the process, entering the space between the metapophyses of the following vertebræ. This is at first double, being in serial continuation with the posterior zygapophysis. The bifurcation grows less marked, and ceases near the end of the lumbars; the spine persists till we reach the 5th caudal, attaining its greatest size towards the posterior end of the lumbar division. To compare this table with Mr. Murie's, it is found that the height of the entire vertebra is with us greatest in the 12th lumbar, though about the same in several adjacent vertebra, while in his table the 1st caudal springs into sudden preëminence. As to the breadth toward the point of the process it is greatest with us in the 10th lumbar, with him in the 6th lumbar.

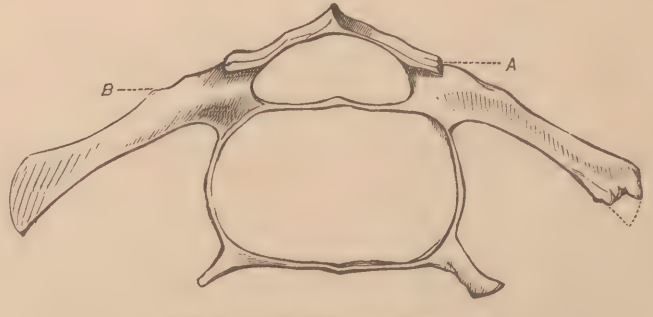


Fig. 6. — 6th Cervical Vertebra.

Transverse Processes (*Diapophyses*). — The inferior transverse processes (parapophyses)

in the cervical region have already been sufficiently mentioned. The great lateral masses of the axis incline strongly backward, particularly towards the upper surface. The processes of the 3d and 4th cervicals have the same inclination to a lesser degree; those of the 5th are about straight, and those of the 6th and 7th incline forward so that the extremities of the transverse processes from the 2d to the 7th cervical very nearly touch one another. All these processes, except the 7th, are exceedingly thin, and that of the 3d dorsal is the first in which the thickness is greater than the height; all the subsequent ones are thin and compressed from above downward. The thin superior edges of the cervical transverse processes present each a small, rough elevation (*B* in woodcuts,) at some distance from the body, which are serially homologous, with a similar projection from the axis. In the 2d and 3d cervicals the transverse processes spring almost entirely from the pedicles, but in the following vertebræ they arise more and more from the bodies. In the first six dorsals the origin is very extensive, for though they really arise from the bodies, the line forming the posterior superior border runs up into the arch. In the 7th dorsal this line disappears and they continue to arise successively lower. In the 5th caudal they arise from a point a little below the centre of the body; in some of the subsequent ones perhaps a little higher, though not above the centre.

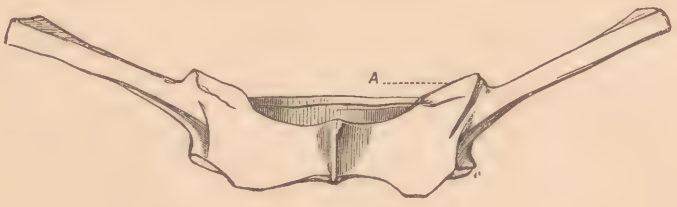


Fig. 7. — 7th Cervical Vertebra.

With regard to shape and direction the first five dorsals incline forward like the latter cervical vertebra; a few are then about straight, after which a slight backward tendency appears. In the 5th dorsal an angle appears in the anterior border and the part external to this is directed backward; this persists throughout the dorsals, and reappears from the 9th lumbar to the 4th caudal. The general backward inclination ends with the anterior lumbars, and after a few vertebræ a forward one is substituted which continues to the end. In the 8th caudal the base becomes long and perforated, and persists so till the 14th, with which the transverse process ceases to exist. The greatest distance between the extremities of the transverse processes of a vertebra occurs in the 2d lumbar, with Mr. Murie in the 4th. The ends of these processes are hollowed in the dorsal region for the tubercles of the ribs. The depression in the first two is at the end, but subsequent ones are hollowed below. The fossa is very deep in the 4th, 5th, and 6th, bounded anteriorly by an oblique ridge which ends internally in a sharp point. The posterior fossæ are less and less

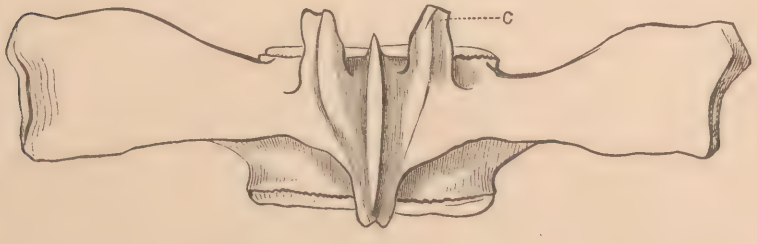


Fig. 8. — 6th Dorsal Vertebra.

marked, and leave the under side of the bone to get on to the posterior corner of the end of the transverse process.

Articulating Processes (*Zygapophyses*). (*A* in woodcuts.) — These are found in the cervical and more or less plainly in the first five dorsal vertebræ. In the 3d cervical the anterior zygapophysis is an oval, smooth surface placed on the outer end of the arch by the origin of the diapophysis, having its long diameter transverse. In the succeeding vertebræ it gradually changes its position so that the long diameter points forward and outward. The surface begins to face inward with the first dorsal. In the 4th, this surface is on the inner side of the metapophyses facing directly inward. In the 5th, it is largely perceptible. The posterior zygapophyses, more or less convex, follow the variations of the anterior ones, though of course in an inverted direction. Those of the anterior vertebræ face backward, those of the posterior outward. They of course get nearer together. It is important to observe that the series of the zygapophyses is continued on to the anterior side of the arch of the axis and to the posterior side of the arch of the atlas. The surfaces on the latter almost meet in the median line. The zygapophyses are clearly continued towards the tail, as the projections at the base of the spinous process already mentioned.

The metapophyses (*C* in cut) are first seen unmistakably in the second dorsal, where a slender pointed process projects forward on either side from the base of the transverse process, a little external to the zygapophysis. In the first dorsal we must hold that this process does not exist, or that it is represented by a small protuberance on the upper edge of the transverse process which is the last of a series already mentioned in the cervical vertebræ, beginning very prominently on the axis. I shall not attempt to decide whether these are to be considered metapophyses, but simply suggest the question. In the 3d dorsal the metapophyses are thicker and continuous with the outer side of the articular surfaces. Those of the two sides now rapidly become closer together, and instead of springing from the base of the transverse process, they soon spring from the base of the spinous, and they appear as two vertical, quadrilateral plates parallel to one another. With the 6th lumbar, the vertical anterior edge begins to be cut away below, and this increasing, they appear nearly triangular. Among the last few lumbars, these plates cease to be parallel, each bending a little outward; this change increases rapidly and in the 6th caudal they are expanded and nearly horizontal. After this they rapidly decrease in size, appearing only as knobs projecting upward and outward, and with the 15th they disappear.

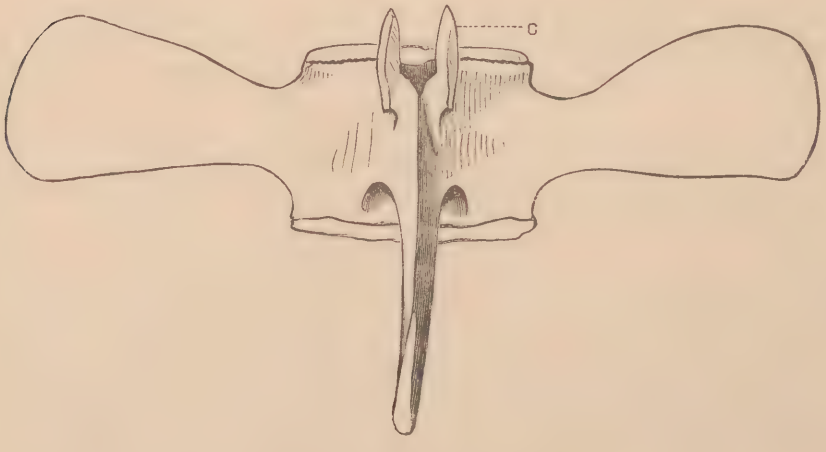


Fig. 9. — 6th Lumbar Vertebra.

Foramina. — The nutritive foramina of the atlas have been noticed. The principal seats of these foramina in the majority of vertebræ are towards the ends of the body, near the root of the transverse processes, and on the upper and lower surfaces of the body near the middle. In the dorsal region the superior foramina are usually two, symmetrically placed side by side, and this arrangement continues with occasional variations. On the lower surface a similar arrangement begins to prevail towards the posterior end of the lumbar region. In the 7th caudal, the anterior edge of the transverse process presents a deep notch; in the 8th its base is broad and perforated by a foramen which continues until all trace of a transverse process is lost in the 14th, after that, one or more foramina in a corresponding position are visible entering the bone, till the last two or three are reached. In the 13th and 14th caudal, the projections at the ends of the vertebra for the chevron bones become united into ridges with a central perforation. Subsequently two proportionally large foramina appear side by side, entering the bone, and persist till the last three. It is very probable, reasoning from analogy, that the perforations of the transverse processes are for vessels, because after these processes have ceased to exist I have found that a wire passed into one of the inferior foramina emerges through the lateral one and if it be then thrust in again can be brought out above. The inferior foramina continue close together, those above become more or less separated; but the communication with slight variations continues the same.

The Spinal Canal. — The vertical and transverse diameters of this canal are about equal in the first two vertebræ; in the remaining cervical the transverse greatly exceeds the other. In the 2d and 3d dorsal the height of the canal increases considerably, and in the 5th, the two diameters are about equal. Shortly afterwards the vertical prevails and the next change is the shortening of the transverse. The last dorsal presents a canal having the form of an isosceles triangle, which continues about the same through the lumbar region. Towards the beginning of the caudal region it becomes smaller, in the 15th it is barely pervious, and in the 16th does not exist.

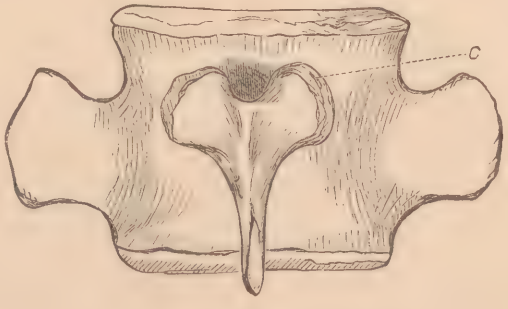


Fig. 10.— 6th Caudal Vertebra.

From this description and a study of the table, the shape of any given vertebra may be pretty accurately deduced, but some further account of the latter part of the caudal region may be convenient. The 15th caudal is a transition from the vertebræ bearing processes to those bearing none. It is the last showing any sign of a spinal canal, which here is so small that one end will not admit the little finger. It is covered by a bridge of bone which shows no signs of a spinous process or of metapophyses. The transverse processes had disappeared in a previous vertebra. The inferior processes for the chevron bones are two mere swellings without the perforation shown in the 13th and 14th. The 16th is about round, without any striking characteristic. The 17th looks rather square and the succeeding ones are decidedly so; they have two foramina close together, on the lower side and two above at some distance apart. The 24th and 25th show a want of regularity and of anything characteristic. The 26th (Pl. VI, fig. 8), the last, tapers towards its posterior end, which

bears a small projecting epiphysis which gives a peculiar finish to the spinal column. The adjacent epiphyses of this vertebra and the preceding one, are grown into one plate about 3-8 of an inch thick, which is nearly smooth on its posterior aspect, but on its anterior presents a central spine which fits into a depression in the 25th.

The Chevron Bones.

These constitute the only part of the skeleton which is not in a satisfactory condition. At the time of the dissection they were so soft that some were cut completely in two by the workmen before they were thought of. There are parts of sixteen bones, but one lateral half of the first and last are wanting, and some others are more or less mutilated so that the correctness of the arrangement which has been adopted is not quite certain. The two sides of the 1st, 15th and 16th had not yet united. The 1st is a thin plate slightly convex on its outer side with an articular surface on the upper end; the inferior end is drawn out backward. The articular surface of the 2d and 3d is also single, after which this surface is divided into two by a transverse ridge till the 11th. The bases become wider transversely in proportion to the size of the bones as we pass backward. The plate forming the arch is constricted at the upper part in the anterior ones (except the first), but becomes broad after the first few. The lower end projects both forward and backward, chiefly in the latter direction. I have not been able to find any regular proportion between the size and the position of these bones.

The following table shows the greatest vertical and longitudinal (from before backward) diameters in inches.

Number of Bone.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Height.	6	8.75	9	8.5	8.25	7.5	8.25	8.75	7	7	6.5	5.5	4.5	3	1.75	1
Length.	3.25	6	6.75	7	6*	6.5	6.5	5.5*	5.75		5.5	5.75	5.5	4	2.25	1.25

Those marked with stars have a little wanting. About a third part of the 10th is wanting.

One peculiarity in the formation of these bones deserves particular notice. They are formed in two lateral pieces which appear to have been put together unevenly, that is one a little in front of the other; thus the anterior edge of one plate is continued directly on the anterior edge of the spine formed by the union of the two, while the front edge of the other falls a little back of it; on the other hand, the posterior edge of the second projects behind that of the first. This appearance is present in all the bones excepting two, both of which are imperfect at important points. The plate on the left side is (with one exception) the anterior one. In most of the larger ones the keel, instead of being in the median line, is somewhat deflected to the right, and the left side of the bone shows a slight concavity suggestive of the depression which would be caused by a large artery.

The Ribs.

The following descriptions and measurements are taken from the ribs of the left side; those of the right present some curious pathological alterations and will be considered later.

There are fifteen pairs of ribs articulated by their tubercles to the ends of the transverse processes of the dorsal vertebræ. The head and neck are well developed only in the

second and third. The first rib is flat and broad, the tubercle turns downward, presents a small articular surface and sends inward a slight prominence representing the head and neck. The angle is marked by an elevation which bends forward; the space between it and the tubercle is convex in front and concave behind, which is the case also in the succeeding ribs. The second rib has on the tubercle a narrow articular surface 4 1-2 inches long. The neck is slender, 4 1-2 inches long and terminates in a small knob for the head. The angle bears a prominence which, unlike that of the first rib, bends backward. The third rib is longer, but the head and neck measure only 3 inches. The angle is more prominent. The neck of the fourth rib is indicated by a very slight prominence. In the subsequent ribs there is no sign of it. The fifth and sixth resemble each other very closely. The latter is the longer one, and the angular prominence is less well marked. There is but a very slight downward projection from the articular tubercle. The succeeding ribs present a similar gradual change; the prominence at the angle is less and less, so as to be hardly perceptible in the 12th. The ribs become narrower and the articulating surface shorter and broader, so that the extremity of each of the four ribs preceding the last is almost globular; in the fifteenth, however, it is oblong. This rib is flat, compressed above and below, and extending directly outward from the vertebral column for 7 or 8 inches, when, becoming narrower, it turns upon itself and points backward and downward, with an external and an internal surface. It has, properly speaking, no angle. The eleventh and twelth ribs present a small prominence on the posterior superior border, apparently for muscular attachment.

The following table gives the greatest length of each rib along the convexity, the distance between the ends in a straight line; and, to show the amount of curvature, the greatest distance from a straight line to the inner surface of the bone. (The measurements are in inches.)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Greatest length.	41	64	70.75	74.5	73.25	75	74.25	71.5	67.75	63.25	59.5	53.5	48	46	47.5
Length in a straight line.	33.5	37.5	47.5	52.75	56	57.25	58.25	54.75	53	51.5	49.25	46.25	44	43.5	45.5
Amount of curve.	8	12.25	14.25	14.25	16	16	16.25	15.75	14.5	13.25	11.5	8.75	5.25	5.25	6.25

On comparing the heads and necks of the first four ribs with the woodcuts of those of the Rosherville skeleton, it is plain that those of this whale are much more developed. The third, though less developed than the second, is as much so as the second of the Rosherville.

The ribs of the right side. — The first five offer no peculiarity. The tubercle of the sixth is rather heavier than that of the other side, and the tuberosity at the angle very much so. A little external to the angle a rough prominence about 8 inches long projects boldly from the upper part of the rib, giving very strongly the appearance of a repaired fracture; the continuity of the inferior edge, however, is perfect. The seventh bears a corresponding, but less marked prominence. The tubercle of this rib is very rough and irregular, as if by the effects of inflammation. It is of double thickness, owing to the projection of an irregular mass from its posterior aspect. The tubercles of the eighth and ninth have similar malformations, but in a less and decreasing degree. The shafts are regular. The succeeding ribs are normal, till the fifteenth, which is a fine specimen of an ununited fracture. The proximal fragment, 14 inches long, corresponds with a like extent of the rib of the opposite side, except in being on a smaller scale and in running gradually to a point.

The second piece, 33 1-2 inches in length, begins above by a sharp extremity, which is considerably bent upon the rest of the bone and points inward. As it grows broader a a small spine appears on either side, after which the bone gradually assumes a normal appearance. These fragments were firmly united by ligamentous structures. The ends exhibit the signs of atrophy rather than any attempt towards reparation.

The Sternum. Plate vi, fig. 10.

This bone is very porous and has suffered some injuries, particularly in the upper and outer part of the right side. It resembles very closely the sternum of the whale in Alexandra Park, figured by Mr. Flower [Proc. Zool. Soc., 1864, p. 393]; but the posterior process is not so long. The only peculiarity of the bone in this specimen is its asymmetry. The inferior surface is, as usual, convex laterally and concave antero-posteriorly. The posterior projection is curved very much to the right, and, to increase the distortion, the lateral projection of the right side bends a little downward and that of the left a little upward. The former of these lateral processes appears to have been originally shorter than the other, but it is impossible to say accurately how much is wanting.

Greatest length in a straight line	12.75 in.	Without any restoration.
" breadth " "	15.75 "	

Anterior Extremity.

Scapula. — This bone agrees very closely with the one figured by Gervais and Van Beneden, except that the outer surface appears more plane.

MEASUREMENTS.

Length of superior border (following curve)	42.37 in.
" in straight line from the posterior superior to anterior superior angle	34.75 "
Greatest height from about middle of glenoid cavity	20.62 "
Length of anterior border to origin of coracoid (in straight line)	15.62 "
" posterior border to back of glenoid cavity	16.75 "
Circumference of neck	23.62 "
Length of glenoid cavity to root of coracoid	9 "
Breadth " "	6 "
Length of coracoid along superior border (about)	4.75 "
Breadth at base	3.5 "
" at point (about)	2.75 "
Length of acromion along inferior border	8.5 "
" " " " superior "	5.5 "
Breadth at point	4.25 "

The superior border is pretty regularly curved, except that towards the last fourth it inclines rather suddenly downward. The external surface is regular and very slightly concave; there is, however, one slight vertical prominence a little in front of its middle, and also a pretty well marked spine running into the acromion, which is thin and bent a little inward at the superior anterior angle. There is a tolerably well marked supraspinous fossa. The anterior edge is sharp; the posterior, particularly near its lower end, thick and rounded. The inner surface has eight slight ridges diverging from the glenoid fossa; the anterior, however, does not reach it. Mr. Murie gives the same number.

The glenoid fossa is irregularly oval and very rough, with projecting edges; it is continued anteriorly into the coracoid process, which is short, solid, and bent inward.

Humerus. — This is a very heavy and solid bone, presenting a broad shaft, a globular head and a tuberosity. On its outer surface the shaft is roughened, except toward the upper and posterior part. A little above the middle there is a considerable depression. The inner aspect presents nothing noteworthy. The posterior side is concave; the anterior is straight. The inferior surface is articular for the radius and ulna. It consists of two parts which meet a little back of the middle in a transverse ridge. The posterior portion, which is for the ulna, does not end on the inferior surface of the humerus, but passes up on to its hinder surface. If the bone be held vertically the globular head (Pl. VI, fig. 11 *a*) projects upward, outward and a little backward. On the inner superior aspect it presents a large depression, from the front of which an ill-defined groove runs downward and outward, corresponding to the "anatomical neck" of human anatomy. From the front of this groove a large and rough tuberosity projects forward and slightly inward. (Pl. VI, fig. 11 *b*.)

MEASUREMENTS.

Length	14.62 in.
Breadth through head and tuberosity	9.25 "
" " about middle of shaft	6.75 "
" " lower end	8.25 "
Thickness through middle of shaft	4.25 "

Radius. — This bone consists of little besides the shaft. Its anterior border is very slightly convex; the posterior rather more than correspondingly concave. The posterior border is thickened at the two ends where it joins the ulna. The anterior border ends above in a small prominence directed forward. On the posterior border there is a large nutrient foramen directed upward.

It should be remarked that the inferior epiphyses which were detached from the radii and ulnæ were very largely cartilaginous, and as only the ossified parts have been retained and replaced, the bones lose something in length.

MEASUREMENTS.

Length	23.37 in.
Breadth at upper end	6. "
" about middle	4.37 "
" lower end	5.87 "
Thickness at about middle	2.25 "

Ulna. — This is a much more delicate bone than the radius. The edges are more curved — the posterior most of all. The anterior edge expands very much in the upper third of the bone. The superior epiphysis forms the articular plate for the inferior surface of the humerus. The olecranon projects backward from about the upper fifth of the bone, and reaches upward so as to fit on to the humerus behind; this part, however, is rough, unlike the rest of the joint. The posterior border of the olecranon is convex; its lower portion very rough. The ulna is expanded at the lower end, where the outer surface is very smooth.

Length (exclusive of olecranon)	22.62 in.
Length of projecting part of olecranon	3 "
Breadth at upper end through olecranon	6.75 "
" " about middle	2.87 "
" " lower end	5.12 "
Thickness at about middle	2 "
Length of olecranon (following curve)	8.75 "
" " " (in straight line)	7.37 "

Manus. — That the number and position of the smaller bones of the flipper might be accurately determined, I placed the undissected left flipper (after it had been separated from the radius and ulna) upon a large sheet of coarse paper, and traced its outline. I then began to remove the skin from one side, and having determined the positions of the bones, traced each of the larger ones upon the paper with slight notes of the peculiarities. The change in the bones by maceration, scraping, etc., has, of course, greatly altered their outlines; but I have been able to identify all the bones of the carpus with great certainty, and though some of the smaller phalanges may have been transposed, yet this (the left) flipper, as now mounted with the bones at the proper distances, may, I think, for all practical purposes be considered absolutely correct. There are six carpal bones, counting one small one on the ulnar side, which is supposed to represent the pisiform bone. The four digits, counting from the radial side, contain respectively five, seven, five and three bones. Before dissection the radial edge of the flipper was thick and rounded, while the ulnar was sharp and thin. The thickest part of the skeleton is through the middle finger (which is much nearer the radial than the ulnar border), and the bones become thinner as they recede from this line, but much more so as they approach the ulnar edge. The bones of the carpus are arranged in two rows; the proximal consists of the radiale, intermedium and ulnare, with the small pisiform beyond. The distal row consists of two; the trapezoid and the unciform (according to the views of Mr. Flower), situated respectively in front of the intervals on either side of the intermedium. Each bone presents two smooth sides which are free; the others being rough for the surrounding cartilage. In the radiale and pisiform alone the two smooth surfaces meet in a rounded border, which lies close to the edge of the limb. The bones of the first row decrease regularly in size from the radial to the ulnar side. The trapezoid is the thickest bone in the carpus, and the unciform the one presenting the greatest extent of surface.

The bones next in order should perhaps be called the metacarpals; but, except in size, they are in no way different from the phalanges. I observed nothing like an epiphysis. The metacarpals of the index and little finger somewhat overlap the carpal bones of the second row. Those of the two intermediate fingers rest upon the trapezoid and unciform respectively. The bases of the metacarpals are thicker than the distal ends. The phalanges of the index differ from all other bones in the hand by a tendency to be slender and cylindrical, while the others are flat and broad.

The flipper of the right side was not dissected with as much care as had been given to the left, which is very much to be regretted, for an additional phalanx was found, and it was not observed whence it came. After studying carefully the appearance of the flipper, and comparing the accounts of the various skeletons in which the number of phalanges has been given, I have decided to place the extra bone on the digit next to the little finger. Thus the formula of the right flipper, beginning at the radial border, will be 5, 7, 6, 3.

It is interesting to notice that all the carpals and almost all the metacarpals and phalanges of the two sides were so like their respective fellows that, with the exception of a very few of the smallest, the position of any bone of the right flipper could be determined by a glance at the left.

Pelvic Bones.

Fig. 11, in text, and Plate VI, fig. 14 (inverted).

One pelvic bone (the left) was removed without being noticed from the body during dissection. When we perceived that the proper place had been passed a long search was made among the pieces of flesh which had been cut off, and the bone at last found. I was so fortunate as to find the bone of the right side in its original position. The rudimentary femur was found on each side. The pelvic bone is thin and triangular. The outer surface is slightly concave; the inner slightly convex. The processes are thicker than the body, particularly the anterior, which is the longest and is flattened below. The inferior border is slightly concave, pretty sharp in the middle, but thick and flat towards the ends. The superior process is broader than the others, but is not much thicker than the body of the bone. The anterior superior border is interrupted by a small notch in the bone of the right side; but that of the left does not show any trace of an indentation.

Fig. 11.

The greatest length of the bone of the left side is 8 1-2 inches; of that of the right side 9 inches. The greatest vertical depth is 3 inches on the left and 3 1-2 inches on the right side.

The rudimentary femora were chiefly cartilaginous; but each contained a semi-ossified nucleus. An error in the dissection made their position a matter of some doubt. They were probably situated in front of the position in which they are drawn.

Organ of Hearing.

The auditory apparatus was not studied in the fresh state; the description therefore refers only to the bones. This specimen differs from those of the *B. rostrata* by the firmness with which the petrous and tympanic bones were fixed in the skull. Drs. Carte and Macalister state that the connection was slight, and that the part in question was removed without much difficulty. In this case, on the other hand, the posterior portion was so much overlapped by the squamous and exoccipital bones, that a large piece of the former had to be removed to free it, as well as a scaly plate belonging to the pterygoid, which covered the anterior portion. The right ear was the only one examined. It presents the usual solidity, weighing three pounds, and is divided into the tympanic bulla and into the anterior, posterior and labyrinthic portions of the petrous bone proper.

The *Tympanic Bulla* presents no peculiarities which appear specific; it resembles the drawing of that bone from the *B. rostrata* quite as much as those from the *B. musculus*.

The longest diameter is 5 inches. The external and inferior surface has five convolutions converging upward; the anterior and posterior of these are the continuations of a longitudinal rough ridge about 3-4 of an inch broad, which divides this surface from the upper one, which is smooth and rolled into the cavity of the bone. The anterior external convolution runs upward and backward to the point of union with the anterior portion of the petrous bone. The second and third, though at first separated by a deep fissure, become somewhat fused together; the former is continued into the malleus; the latter into a bold prominence forming the anterior boundary of an opening, which, on the authority of other writers, I consider the meatus externus. The fourth convolution bounds this notch behind, and the fifth terminates on the posterior end of the bone, a little below the point at which the posterior portion joins it.

The anterior and posterior portions unite with the bulla at their respective ends; the labyrinthic, situated at the junction of the two former, is united with the tympanic by the chain of ossicles, which may be appropriately considered now.

The Malleus. — The absence of the membrana tympani at the time of the examination is much to be regretted, as it causes the loss not only of any observations on its position, but also of any on the homologies of the malleus. This bone is coössified with the bulla by a process presenting a deep groove anteriorly, which I am inclined to consider the processus longus. The remainder of the bone consists of two prominences tolerably well separated by a groove; the posterior and larger one is the head; it presents two articular surfaces, which meet at an acute angle; the larger one of these is about vertical, looking backward and inward; the smaller is convex and its general position is horizontal. The anterior prominence represents the manubrium; a small tubercle on its outer side closes the groove dividing it from the head, and may be considered the homologue of the processus brevis. On its inner side is a horizontal ridge, possibly for the insertion of the tensor tympani. Near its base the manubrium is pierced by a minute canal.

The Incus has the general outline of a cone with a bent apex. The bone projects backward and inward. The base is formed by two unequal articular facets, which fit perfectly with those of the hammer. The short process is a mere tubercle on the posterior aspect. The long process is bent upward, and ends in a small oval articulating surface for the stapes, separated from the upper side of the bone by a well marked groove.

The Stapes is placed rather obliquely, the long diameter of the plate running forward and inward; it presents for description a head, two crura and a base. The head has no definite boundaries; there is an oval articular surface on its extremity surrounded by a groove. On the anterior aspect, just before the origin of the crus, there is a rough elevation for the insertion of the stapedius. The posterior crus is the larger and the straighter; the anterior being slightly curved inward. The base is oval to fill the fenestra ovalis, and is broadest near the anterior end. On the outer aspect the crura diverge so as to leave the entrance to a comparatively large passage between them, which is, however, nearly closed by a plate of bone on the inner aspect.

The Petrous Portion. — *The posterior division* is 12 inches long, constricted at its origin, but broad and expanded towards its extremity. It lies in a groove between the squamosal and the exoccipital. Its inferior surface is the only one which presents any points for description. Towards its anterior end it is marked by a deep groove, which at one point is almost made into a canal by a plate projecting from its inner side, and which

runs into the bone at the junction of the anterior and middle divisions. It is the continuation of the aqueductus Fallopii. Beside this one is quite a minute groove apparently for a small vessel or nerve.

The anterior portion is a three-sided pyramid pointing nearly straight forward. The inner side is rough; the others tolerably smooth. There is a considerable prominence near the base on the outer aspect.

The middle or labyrinthic division is the most important, as it contains the vestibule, the cochlea and the semicircular canals. It is conical in shape, the apex being perforated by two foramina of equal size — about one-half inch in diameter — the aqueductus Fallopii anteriorly and the internal auditory meatus posteriorly. In this respect it is very different from that of the *B. rostrata*, as described by Drs. Carte and Macalister. The aqueductus perforates the bone, and changing its course, reappears at the base of the labyrinthic portion and is continuous with the groove in the posterior division. A small canal opens on the anterior aspect of the labyrinthic part. It is found to open into the aqueduct, and is probably for the passage of the chorda tympani. Towards the posterior edge of the upper surface there is a deep funnel-like depression, which, as far as I can ascertain, has no opening at its lower end. Directly internal to this, guarded at its orifice by a bony spine, is the aqueductus cochleæ, which opens into the scala tympani a little inside the fenestra rotunda. I have found nothing to represent the aqueductus vestibuli. The fenestra ovalis is situated in the depths of the cavity of the tympanum, and is surrounded by a raised wall. The fenestra rotunda is, as is usual in Cetacea, considerably removed from the ovalis, being posterior and external to it.

The cochlea was chiselled out by removing with great labor a part of the internal aspect of the bone. It consists of nearly 2 1-3 turns, which is more than I have found described for any whale — the *B. rostrata* having two turns, according to Carte and Macalister, and 2 13-360, according to Hyrtl. With regard to position, the modiolus appears to point very nearly downward when the bone is in place. The scala tympani, as usual in Mammalia, is at first larger than the scala vestibuli, and then smaller. Where the preparation has been slightly broken it is easy to see the spiral canal formed by a cavity in the lamina spiralis described by Hyrtl as peculiar to Cetacea. There is no trace of a lamina spiralis secondaria. The bone was exceedingly brittle and the preparation very difficult, so that the semi-circular canals were quite destroyed — the only description I can offer of them is that they were very minute.

Classification.

From this description there can be no doubt that this is a specimen of the *Physalus antiquorum* of Gray, or the *Balænoptera musculus* of authors and most recently of Van Beneden. The classification of the latter has been chosen as the most "conservative," and the one allowing the greatest scope to individual variation. Whether the Darwinian hypothesis be accepted or not, the opinions of Mr. Darwin on individual differences and on the formation of species and varieties are entitled to the greatest respect, and the following quotations from the second chapter in his "Origin of Species" are very much to the point: "These individual differences generally affect what naturalists consider unimportant parts; but I could show, by a long catalogue of facts, that parts which must be called important,

whether viewed under a physiological or classificatory point of view, sometimes vary in the individuals of the same species. I am convinced that the most experienced naturalist would be surprised at the number of cases of variability, even in important parts of structure which he could collect on good authority, as I have collected during a course of years." "Wide-ranging, much-diffused and common species vary most." "Species of the larger genera" (that is, those having the greater number of species) "in each country vary more frequently than the species of the smaller genera." Now, according to Prof. Van Beneden, all the finners are included in one genus —*Balænoptera*, which is spread throughout the seas, and comprises several species. The *B. musculus* is probably the largest species in point of numbers, and likewise the most widely spread, and *consequently* the one presenting the greatest variations. Distinctions based on the bifurcation of the first rib have been shown by Van Beneden, and subsequently more in detail by Mr. Turner[1] to be of very little value.

It now remains to show how much variation exists by comparing the Boston skeleton and several others one with another. Before dissection the chief peculiarity was the thickness of the body in proportion to its length; this may partly have been due to distention; but the cranium was very uncommonly large, forming a fourth of the length in the flesh, and naturally more in the skeleton. Mr. Flower's drawing in the Proc. Zool. Soc., 1869, represents not only a more slender animal, but one with a more solid and projecting lower jaw. The drawings and measurements of the so-called *P. Duguidii* represent a very narrow body and beak; the flippers are rather longer in proportion. Slight differences in the position of the anterior limb and the dorsal fin are to be found by comparing the measurements of several individuals, but nothing worthy of particular notice.

On comparing the upper aspect of the skull (Pl. VI, fig. 1) with that in Van Beneden and Gervais' "Osteographie," with that in "Recent Memoirs on the Cetacea" by Eschricht, Reinhardt and Lilljeborg (Ray Society, 1866, Pl. III, fig. 3), with that of Eschricht's Nordhval and the Rorqual de la Mediterranée in Cuvier's Ossemens Fossiles, I find that though in several points resembling each, in others it differs from all; it is perhaps most like the last mentioned.

The diversity of the proportions of the breadth of the skull and of the beak to the length of the skull, the latter being taken as one hundred, is very well shown in Mr. Flower's table, Proc. Zool. Soc., 1864, p. 399. In the following table I reproduce his cases of the *P. antiquorum*, adding to them those of the animal taken at Margate, and described by him Proc. Zool. Soc., 1869, three from Lilljeborg's Scandinavian Cetacea and the Boston Whale, calculating the proportions in the same manner, but omitting fractions.

PROPORTION TO LENGTH OF HEAD.

Specimen.	*Breadth of Skull.*	*Breadth of Beak.*	*Specimen.*	*Breadth of Skull.*	*Breadth of Beak.*
Antwerp.	52	18	Margate.	44	17
Louvain.	44	18	Christiania.	45	
Alexandra Park.	46	19	Bergen.	47	
Rosherville Gardens.	45	20	Young (described by Companyo)	37	
(Young) Leyden.	48	21	*Boston.*	46	19
(Young) Mus. R. Coll. Surg.	50	20	Average.	45.81	19.25

[1] Journal of Anatomy and Physiology, vol. V.

This table is, of course, open to objection on the score of perfect accuracy; but it shows clearly that if drawings of all these were placed together, that the diversity of shape would be very striking. In some cases both skull and beak exceed the average breadth; in others both fall short of it, and again, in others sometimes one part, sometimes the other is out of proportion.

The nasals in the Boston whale are very short in proportion to their width, and perhaps are rather smaller than usual. The shape of the supra-occipital is different in all the plates lately referred to; in this specimen, however, it has the narrowness above and the breadth below, which Van Beneden considers a specific character. The supra-orbital plates are remarkable, inasmuch as the inner border is decidedly shorter than usual, thus making the anterior edge less oblique.

The variation in the degree of ossification of the rings of the cervical vertebræ is so generally admitted as to require no comment, unless it be that the non-union in the third is remarkable. The cervical vertebræ are interesting, as in connection with those other specimens they are fatal to the validity of one of the characteristics of the species *P. Duguidii*. The atlas and axis resemble respectively Gray's figures for the *P. Duguidii* rather than those of the *P. antiquorum*. Mr. Murie states that the atlas of the Rosherville Whale approaches that of the former, but the axis that of the latter.

Mr. Heddle, in his paper on the Laman and Copinshay whales,[1] subsequently the *P. Duguidii*, states that in them the transverse processes fall somewhat from the plane of the body, while in the *P. antiquorum* they rise; a little study shows, however, that the difference is usually by no means so great as represented in his diagrams. The fifth cervical of the Rosherville Whale is more like that of the *P. Duguidii*; the same bone in the Boston is more like that of the *P. antiquorum*, but its body is larger in proportion.

The most remarkable point about the vertebral column of this specimen is that it is formed of sixty-three vertebræ, which is one more than has ever been described in this species.

The anterior ribs present a curious variation in being more developed than in the Rosherville whale, although the latter was fully adult.

When the large number of points in which this whale is peculiar is considered, it cannot be denied that bolder feats in classification have been attempted than would be requisite to found a new species on this specimen. Such a course, however, would be quite unjustifiable. It is to be particularly noticed that these variations do not point in any one direction; that if in certain aspects this specimen approaches a certain other, yet in others equally important, it may resemble a third which is quite unlike the second, and in still other respects be different from both. A slight study of the writings of the eminent observers so often quoted will be sufficient to show that the same is true, to a greater or less extent, of perhaps every well described specimen of the species.

In the course of time a greater subdivision will perhaps be warranted, but the best nomenclature is one broad enough to be strengthened and not destroyed by progress.

Before concluding I would express my sense of the kindness of my friend H. G. Curtis, Esq., who made the drawings for all the figures in Plate VI, and all those in the text, except 1 and 2, by Mr. Blake, and 10 and 11.

[1] Proceedings Zoölogical Society, London, 1856, p. 187.

Explanation of Plates.

PLATE VI.

Fig. 1. Superior aspect of skull; *a* and *b* mark certain prominences on the supra-occipital mentioned in the text; *c*, edge of parietal; *d*, frontal; *e*, orbital plate; *f*, vomer; *g*, superior maxilla; *h*, intermaxilla; *i*, nasal.

Fig. 2. Inferior aspect of skull; *a*, exoccipital; *b*, articular portion of squamosal; *c*, periotic; *d*, alisphenoid; *e*, orbital plate; *f*, groove from optic foramen; *g*, vomer; *h*, palatal; *i*, superior maxilla; *j*, intermaxilla; *k*, molar; *l*, lachrymal.

Fig. 3. Anterior aspect of Atlas; *a*, tubercle at origin of transverse process.

Fig. 4. Superior aspect of Atlas; *a*, tubercle at end of articular surface; *b*, true articular surface; *c*, same as in fig. 3.

Fig. 5. Anterior aspect of Axis; *a*, odontoid; *b*, points to tuberosities on diapophyses; *c*, true articular process.

Fig. 6. Posterior aspect of Axis; *a*, zygapophysis.

Fig. 7. Lateral " "

Fig. 8. Last (63d) Vertebra. *Natural size.*

Fig. 9. First rib.

Fig. 10. Anterior surface of Sternum.

Fig. 11. Humerus.

Fig. 12. Radius.

Fig. 13. Ulna.

Fig. 14. Left Pelvic Bone (*drawn inverted*).

PLATE VII.

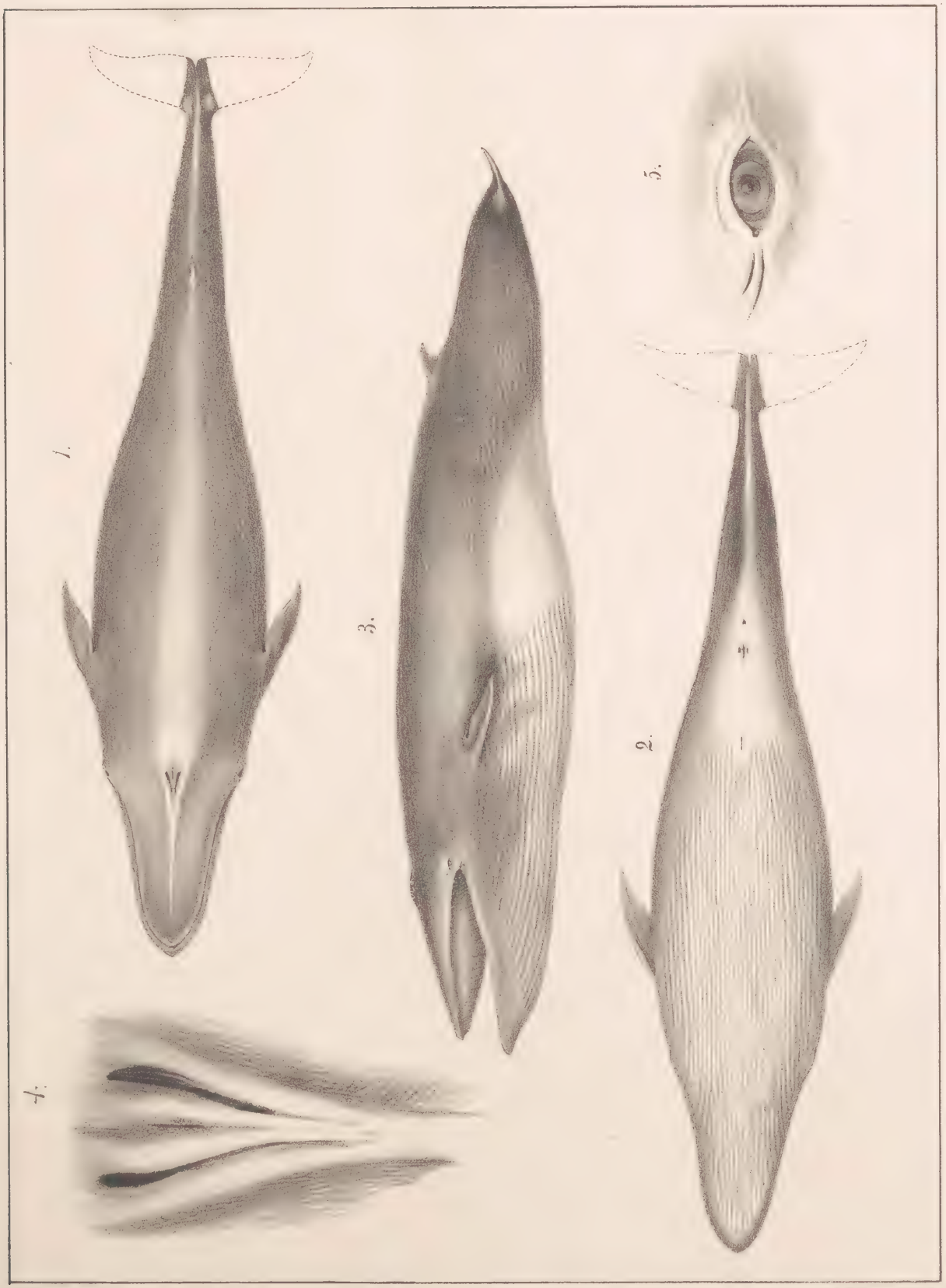
Fig. 1. Dorsal aspect of Whale.

Fig. 2. Ventral " " "

Fig. 3. Lateral " " "

Fig. 4. Blowholes.

Fig. 5. Eye.



DWIGHT ON THE BALÆNOPTERA MUSCULUS.

H. G. Curtis del.

J. H. Daniels Lith.

DWIGHT ON THE BALÆNOPTERA MUSCULUS.